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# AUTOMATION OF SUPPLY CHAIN MANAGEMENT BY RFID AND XBEE NETWORK

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**ABSTRACT:**

All organizations aim to increase productivity and minimize wastes in terms of expenditure, energy, movements, time and other factors. Scope of this aim is not only limited to manufacturing sector but also includes services and transport/ logistics industry. Barcode technology is used for scanning items in various processes and industries due to easy implementation and low cost. But, it needs human intervention to scan each item individually. It cannot scan dirty, damaged or moving items. To overcome this problem, Radio Frequency Identification (RFID) wireless technology is used for items identification. It does not need human intervention. It can scan multiple and moving items at once. Integration of RFID with Xbee wireless communication network is easy to implement and can be able to increase the communication range. In this paper, a novel approach of Laboratory Virtual Instrument Engineering Workbench (LabVIEW) control platform integrated with RFID system has been presented. This system provides visibility of items at various stages of supply chain on real time basis.

## 1. INTRODUCTION:

Supply chain management (SCM) is the efficient control of the transaction of goods and services. It comprises the movement and raw materials storage, inventory in process and finished products from initial stage to the end point. The SCM is the cycle of raw material supplier to the manufacturer followed by distributor, retailer and customer [1] as shown in Fig 1.1.

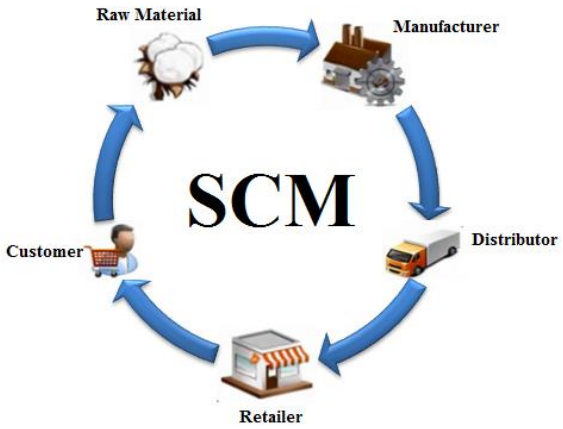


Fig. 1.1 Supply Chain Management (SCM) Cycle

The aim of every SCM is to reduce operational cost minimize wastage and increase profit. It can be achieved by real-time flow of information, product, and funds. It needs an advanced technology to monitor and control. RFID is an advanced auto-ID wireless technology used for real-time tracking and identification of an items without human intervention [2].

Most of the countries are using barcode technology for identification of items, which needs human intervention to scan each item individually. It's a time-consuming activity and may happen a chance of human error by missing of an item during scanning process. To overcome this problem RFID wireless technology is used to scan items automatically by radio frequency. Its further advantages are to scan multiple and moving items at once [3]. It also can scan in dirty and harsh environment. It can scan at longer distance and waves are passing inside the human body as well as non-metallic materials. RFID tag has large data storage capacity. The efficiency is higher in terms of accuracy, speed, quality and flexibility of operation.

### 1.1. RADIO FREQUENCY IDENTIFICATION (RFID) TECHNOLOGY:

Radio frequency identification (RFID) is a wireless technology used for automatically tracking or identifying the entities by radio waves without line of sight in real time visibility of enterprise operations in an indoor system. RFID works on dissimilar frequencies such as LF, HF, UHF and Microwave to fulfill the different requirement. RFID system has three basic components. 1) RFID tag (data carrying device), 2) RFID reader (transceiver) and 3) middleware as shown Fig 1.2. The working principle begins when RFID reader transmits radio frequency wave signal to the tagged items, which contains the microchip (data storage device). When it receives the radio wave signal, immediately activates and send response back radio wave signal along with data towards RFID reader. That data drives to the middleware, which filters and sort the data and send important information to the main business software to monitor and control the SCM [4]. It provides real-time information of each item in SCM at various stages [5].

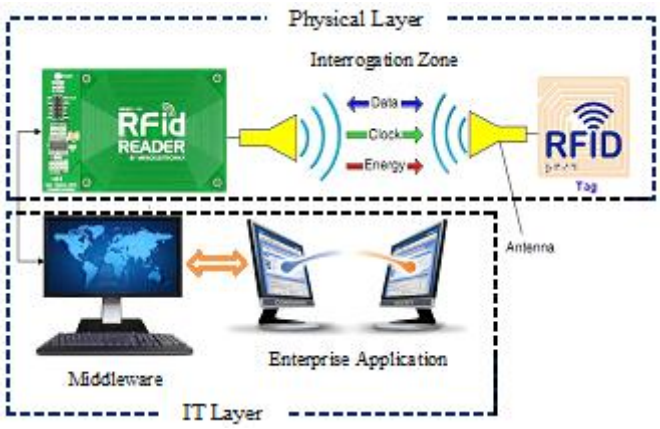


Fig.1.2. Typical RFID System [12]

There are various application areas of RFID including manufacturing, logistics, asset tracking, retailing, warehousing, healthcare and SCM etc [6].

### 1.1.1. RFID TAG

The basic function of RFID tag is to identify the item similar to the barcode tag. RFID tag comprises of an antenna and an integrated circuit called microchip, which is used for sending a response back to the reader. Microchip stores items information including Model No, serial No and other characteristics of object, it may comprises price, weight, size, color and date of manufacture etc [7]. Tags are classified by power usage, storage memory and communication method between tag and reader as shown in Table 1.

TABLE 1. Classification of RFID tags [8]

| **Type of tag** | **Power usage** |
|---|---|
| Passive | Power receiving from RFID reader called as 'reflective powered'. It is small and virtually unlimited life span. |
| Semi-passive | Battery is used as a power source to retain memory in the tag and to modulate the reflected signal. |
| Active | Powered by Internal battery having longer read range and more expensive than passive tags due to (read/write) provision. Batteries are periodically replaced |
| Memory | Application |
| Read-only | Memory is programmed by factory once manufactured cannot be modified. Limited data can store commonly 96 bits of information |
| Read-write | Read and write provision. Store larger data from 32 kb to 128 kb, more expensive than read-only chips, used only for tracking expensive items |
| Method | Communication process |
| Induction | Electromagnetic proximity or near field inductive coupling. Generally, use LF and HF |
| Propagation | Far field or broadcasting electromagnetic waves<br>Operates on UHF and microwaves frequency bands |

The data of item stored into the tag memory as unique Electronic Product Code (EPC). It is used to signal back to the reader to identify the object to which the tag is attached. Tag might be attached to a pallet, case, and entity etc. The environmental sensors can be attached to the tag to measure environmental constraints like temperature and humidity. The sensors information may communicate with the integrated circuit, and then sends to RFID reader.

### 1.1.2. RFID READER

RFID reader is a device which communicates with tags. It consists one or more than one antennas and the interrogator circuitry (IC). Antenna is used to transmit or receive radio wave signal along with the data to/from the tag to identify the object. The reader integrated circuit is an intermediate between the reader antenna and the IT layer [7]. Reader circuit is used to transmit and receive data through reader antenna and send back for processing. It coordinates between various reader's antennas for efficient tags reading. The interrogation zone is the three-dimensional space between reader and tag which is used for communication.

### 1.1.3. MIDDLEWARE

Wired or wireless physical network is used to sends and collects data directly from RFID reader. It executes a business-related process concerning the data. It carries, stores and sends to the enterprise applications as needed. Middleware is the intermediate between the reader and the enterprise application [9].

### 1.1.4. ENTERPRISE APPLICATION

It is the special designed software used for various features of a firm's operation and processes including finance, inventory control, manufacturing, human resources, marketing, sales and resource planning [10]. The supply chain management sustainability can be controlled by decent mechanism throughout the life span of goods and services. The aims of supply chain sustainability is to produce, protect and develop long-term planning of environmental, social and economic issues for all entrepreneurs which are involved in bringing products and services into market. This objective can be achieved by real-time exchange of information using RFID system. This system can easily add with the Xbee wireless network to enhance the communication range.

## 2. XBEE (ZIGBEE) WIRELESS MESH NETWORK:

Xbee is the low cost, low power eating and low rate of data transmission wireless communication device working as mesh network. It is used to enhance the communication range. Wireless transceivers technologies generally operates on frequency bands to share with numerous users at different Radio Frequency (RF) schemes. In specific WiFi, Bluetooth and latest Zigbee, these technologies are used to enhance communication range of the RFID reader. They all three operate on the unlicensed 2.4 GHz Industrial, Scientific and Medical (ISM) band [11]. Table 2. shows the comparison of wireless technologies [12].

TABLE 2. Comparison of wireless technologies

| Characteristics | Zigbee | Wi-Fi (802.11n) | Blue Tooth |
|---|---|---|---|
| Data Rate | 20,40 and 250 Kbps | 2 to 200Mbps | 24Mbps |
| Range (meters) | 1-300 | 1-100 | 1-10 |
| Frequency | 868MHz, 900-928MHz, 2.4GHz | 2.4 & 5 GHz | 2.4GHz |
| Complexity | Low | High | High |
| Battery life (days) | 100-1000+ | 1-5 | 1-7 |
| Nodes per network | 255/65000+ | 30 | 7 |
| Topology | Star, Tree, Mesh | Tree | Tree |
| Standby Current | 3 x 10 -6 amps | 20 x 10 -3 amps | 200 x 10 -6 amps |
| Memory | 32-60KB | 100KB | 100KB |
| Protocol Stack Size | 4"32KB | 100+KB | ~100+KB |
| Stronghold | Long battery life, low cost, low data rate | High data rate | Interoperability, cable replacement |
| Applications | Remote control, battery-operated products, sensors | Internet browsing, PC networking, file transfers | Wireless USB, handset, headset |

It provides high flexibility in node placement, which is based on IEEE 802.15.4 standard. Its benefit is to increase large wireless network at any stage [13-15].

## 3. RESEARCH AIMS:

To minimize efforts in terms of operational cost, reduce wastage and maximize profit within allocated resources.

## 4. RESEARCH APPROACH:

The novel approach of LabVIEW Graphical User Interface (GUI) system works on single control platform to monitor visibility of items in SCM on real-time basis according to the following steps.
*Step 1.* Make three control tabs at front panel window of LabVIEW platform named “indicator” tab, “parameter setting” tab and “address source file” tab.
*Step 2.* Browse the established UDL file at “Address Source File” tab and fill-up the names of vehicle table and items table in required fields to linkage with M.S Access database.
*Step 3.* Select the tab “Parameter Setting” and to fill up all the fields by required parameters.
*Step 4.* Select “Indicators” tab and press run button to operate integrated system. The RFID-Xbee wireless setup being worked according to the algorithm into the developed system. The RFID tag is attached with vehicle of raw material. During entrance into the door of factory, the RFID reader identifies it by unique product code as vehicle No. only those vehicles which are registered in the database. It shows status as “Available” with green light signal and its complete data below the green

light signal at the control panel, if vehicle is not registered in the database, it indicates red signal with status “Not Available”.

*Step 5.* Keep it register the vehicle by inputting the data of vehicle in required fields, e.g. (Registration No, Type of Vehicle, Company name, Driver Name, Driver IC and License) as mentioned in Fig 1.3. After filling up the data of vehicle in the mentioned fields at front panel within permitted time, keep it identity again to move the tagged vehicle in the range of RFID reader, it indicates green light signal along with full data and it shows the status as “Available”.

*Step 6.* Keep it continue for items identification, the RFID reader identifies it with unique ID code and shows the status in the field of “Item code”; also indicates green light signal along with data showing below the green light indicator. The status shown as “Available” at the front panel, otherwise shows red light signal with status “Not Available”, in case of items data not available in the database.

*Step 7.* The LabVIEW program has provision for data entry of item within programmed period for updating the database, to ensure keep it update.

*Step 8.* Keep the items identify again by moving the RFID tagged item slowly near the RFID reader range, it instantaneously identify the item, if it shows green light signal at the control panel with full data, it means the item in the database updated, if it shows red light signal, repeat the earlier procedure until shows green light signal. When all items identifies with green light signal, it shows the database updated for items identification. This system proves the real time information of items identification and data updating during identification or tracking process.

This system can be applicable for sustainable manufacturing, supply chain management, car parking, office automation and hypermarket for item pricing. This system can be modified according to the need-based approach. The benefit of this system is to provide visibility of items at a single control platform. The visibility offered by system could help to reduce losses in terms of wastage of time expenditure and services. It also can lower inventory levels, distribution and handling costs. Integrated system allows products to be followed in real-time scanning across the supply chain providing accurate and detailed information of all items with increased efficiency. Inventory visibility can be used to achieve gains in areas such as faster response to customer demands and market trends, improving the ability to have the right product in the right place at the right time.

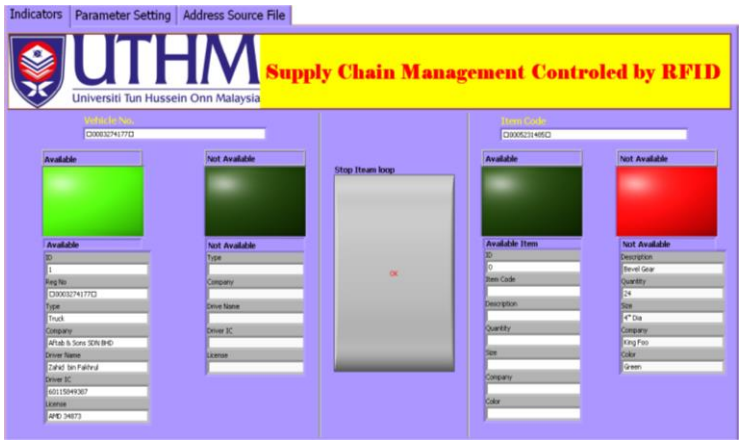


Fig. 1.3. Monitoring by LabVIEW Control panel

## 5. SUMMARY:

RFID-Xbee wireless network system integrates with LabVIEW GUI, which provide complete picture of visibility of items at a single control platform. This system has great provision to identify entities on real time basis. It decreases human error, optimize inventory control and escalate productivity as well as information accuracy at indoor heterogeneous network of sustainable economic advantage. Moreover, the power eating of the system is minimized by using low power hardware. The tracking range of RFID reader can also be improved with Xbee wireless devices; so that beyond range items can be tracked easily without additional RFID readers.

For future work, the Global Positioning System (GPS) and WSN can be joined with the above system which can observe indoor as well as outdoor real-time tracking and identification of items features. It also can sensing environmental parameters with more visibility which reduce the tracking time span.

## 6. ACKNOWLEDGEMENTS:

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